

Electric charge

Electric charge is an intrinsic property of matter. An object can have positive or negative charge, or it can be neutral. In the international system of units (SI), the unit of charge is the “Coulomb”.

Nowadays, we believe that the fundamental unit of charge is that of the electron, which has a negative charge of $1.6 \times 10^{-19}\text{C}$.

$$e^- = 1.6 \times 10^{-19}\text{C}$$

Coulomb's Law

Coulomb's law describes the force between charged particles. Coulomb found that it is given by:

$$F_{q_1q_2} = k \frac{q_1q_2}{r^2}$$

In this context, a positive force is a repulsive one, whereas a negative force is an attractive one. As a consequence,

Equal charges repel each other
Opposite charges attract each other

Homework

Problem 1. The number of atoms in a penny is about 10^{22} and the total number of electrons is of the order of 10^{24} . The charge of each electron is -1.6×10^{-19} C. If you could possibly separate the electrons from all the nuclei in a single penny, how much total charge would you get from the electrons?



Problem 2. The factor of r^2 in the denominator of Coulomb's law has very important consequences. Forces that have this dependence on the distance are known as "inverse square laws". One of the most obvious consequences is the fact that as objects get closer and closer, the force becomes much stronger at each step. To see this, calculate the force between an electron and a proton at a distance of 1m, $1\text{mm}=10^{-3}\text{m}$ and $5.29 \times 10^{-11}\text{m}$ (this is the distance between the electron and the proton in a hydrogen atom).

Homework

Bonus problem (Optional). One of the first experiences that humans had with static electricity comes from what we now know of as the “Triboelectric effect”, in which some insulating objects become charged after being rubbed. For example, when you rub a balloon in your head the balloon gets **negatively** charged and your hair gets **positively** charged. Using this information, your mission is to determine the type of charge that different objects in your house may have.

Object	Type
Balloon	-
Human hair	+
Small pieces of paper	
Small stripes of aluminum	
Food wrapping plastic	
Plastic pen	
Scotch tape	

Object	Type
Cotton	
Glass	
Polyester	
Silver or gold	
Nylon	
Polystyrene	

Tips:

- First, get a balloon and rub it in your hair to get it charged. You can bring this close to many objects in the list and see its direct response.
- Bring the balloon close to small pieces of paper.
- To charge the plastic pen, rub it with a cotton t-shirt. Then, bring it close to the pieces of paper.
- To charge glass, rub it with polyester and bring it close to the pieces of paper